Upper ocean heat budget in the southeast Pacific stratus cloud region using eddy-resolving HYCOM

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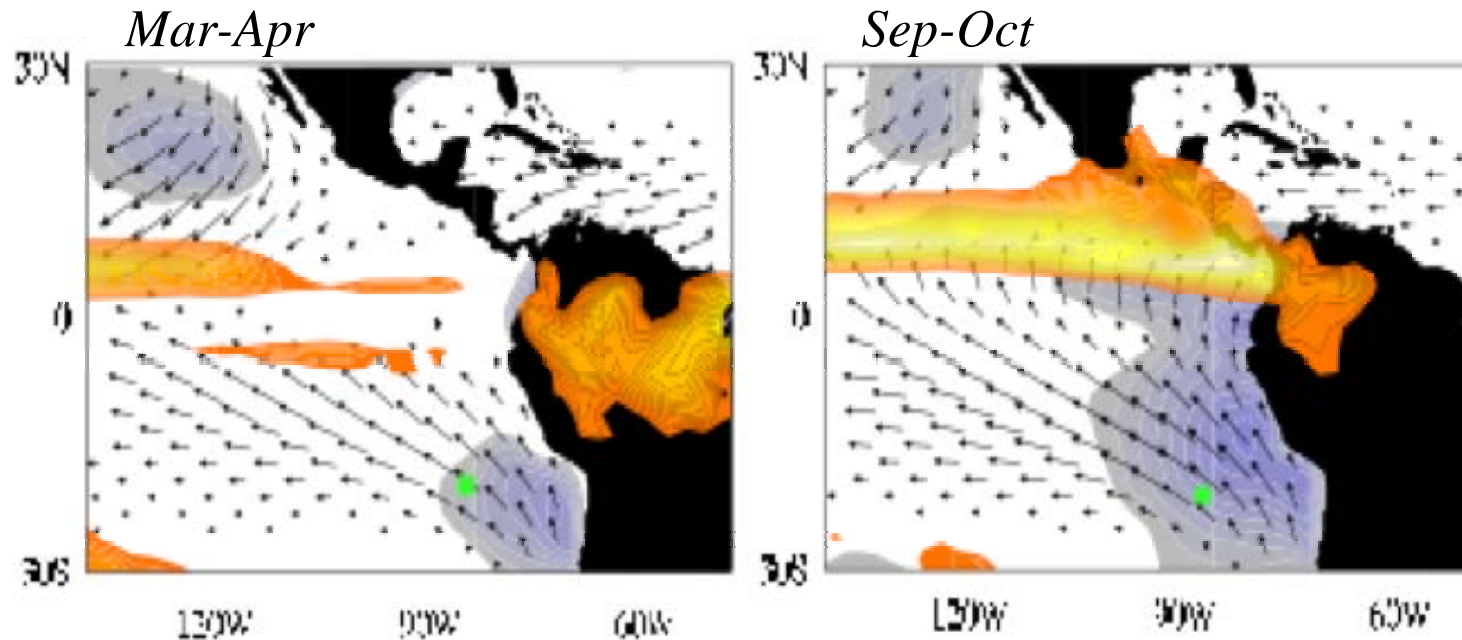
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Mar-Apr　　　　　Sep-Oct

Stratus cloud decks ===> important role in regional and global climate

Most coupled GCMs have problems in producing realistic stratus clouds.

Upper ocean processes that control SST is crucial for simulating stratus clouds

Surface mooring measurements by WHOI since October 2000 (Colbo and Weller 2007)

New campaign: VAMOS Ocean-Cloud-Atmosphere-Land Study (VOCALS)
    Intensive Observations: VOCALS Regional Experiment (Oct. 2008)

Upper ocean heat balance (upper 250m) at the buoy site (Colbo and Weller, 2007)

Term	Estimate (W/m2)	Data
Surface heat flux	44 (± 5)	IMET buoy
Horizontal heat advection by Ekman transport	6 (± 4)	QuikSCAT winds Satellite SST
Horizontal heat advection by geostrophic transport	-20(± 5)	IMET velocity, temperature Historical temperature
Ekman pumping	2.5(± 5)	QuikSCAT winds IMET temperature
Eddy flux divergence	-30	Residual
Vertical diffusion	-3(± 2)	IMET temperature

Hypothesis (Colbo and Weller 2007)

*"We postulate that the eddy flux divergence represents the effect
of the cold coherent eddies formed near the coast.....
the upwelled water does influence the offshore structure, but
through the fluctuating mesoscale flow not the mean
transport."*

Issues

Upper ocean processes which balance the positive (warming) surface heat flux

Representativeness of the IMET site for the entire stratus cloud region

Role of eddies

Models

Global HYCOM

Horizontal resolution: 1/12 deg. X 1/12 deg.
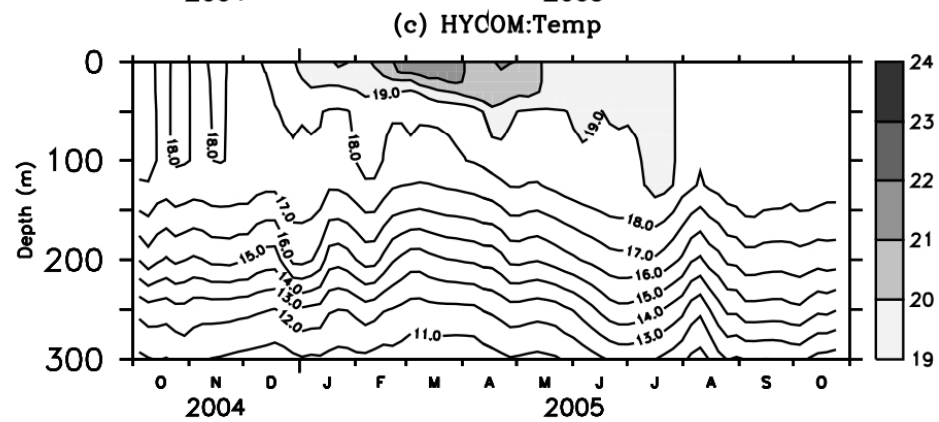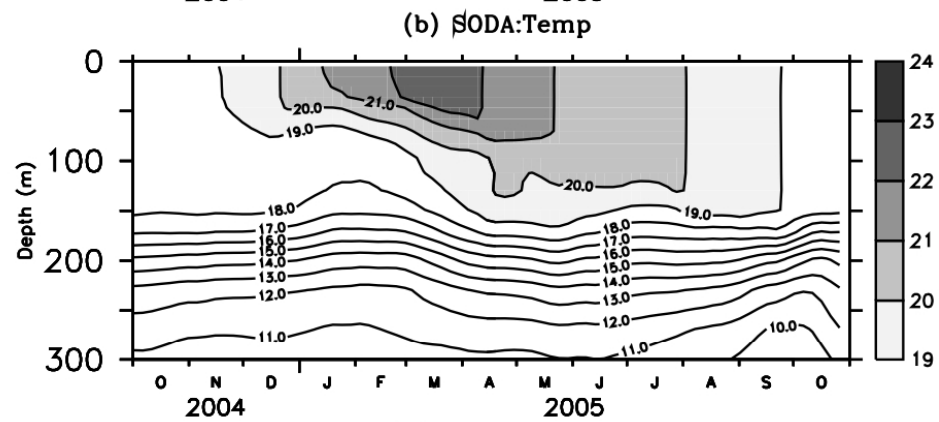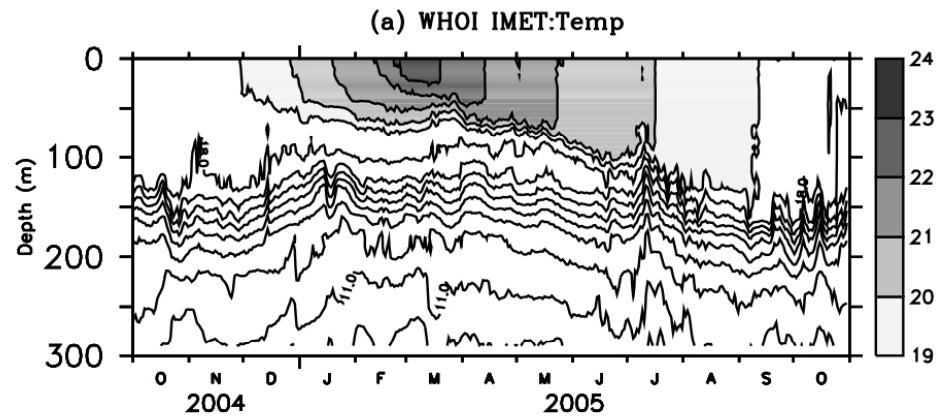*Period: Jan. 2003-Apr. 2007*
No data assimilation

SODA

Horizontal resolution: 0.4 deg. (lon) X 0.25 deg.(lat)
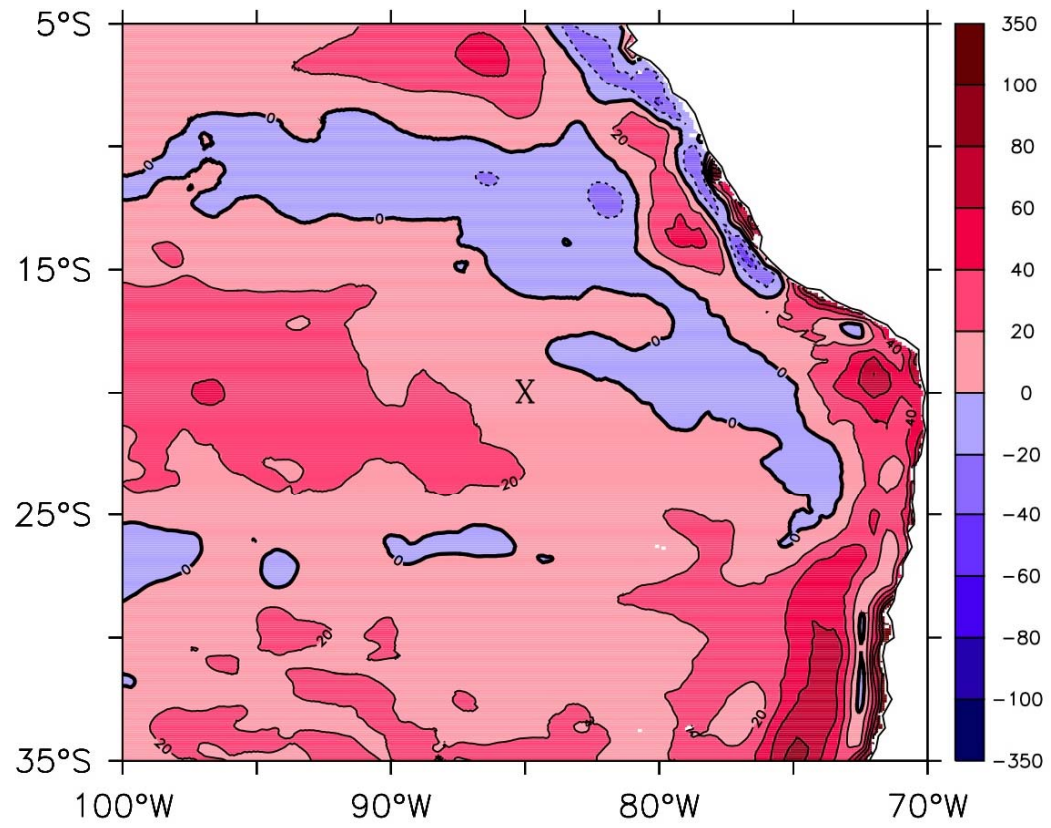*Period: 1980-2005*
Data assimilation

Relative importance of horizontal advection and eddy flux
divergence for the upper ocean heat balance

(a) WHOI IMET:Temp

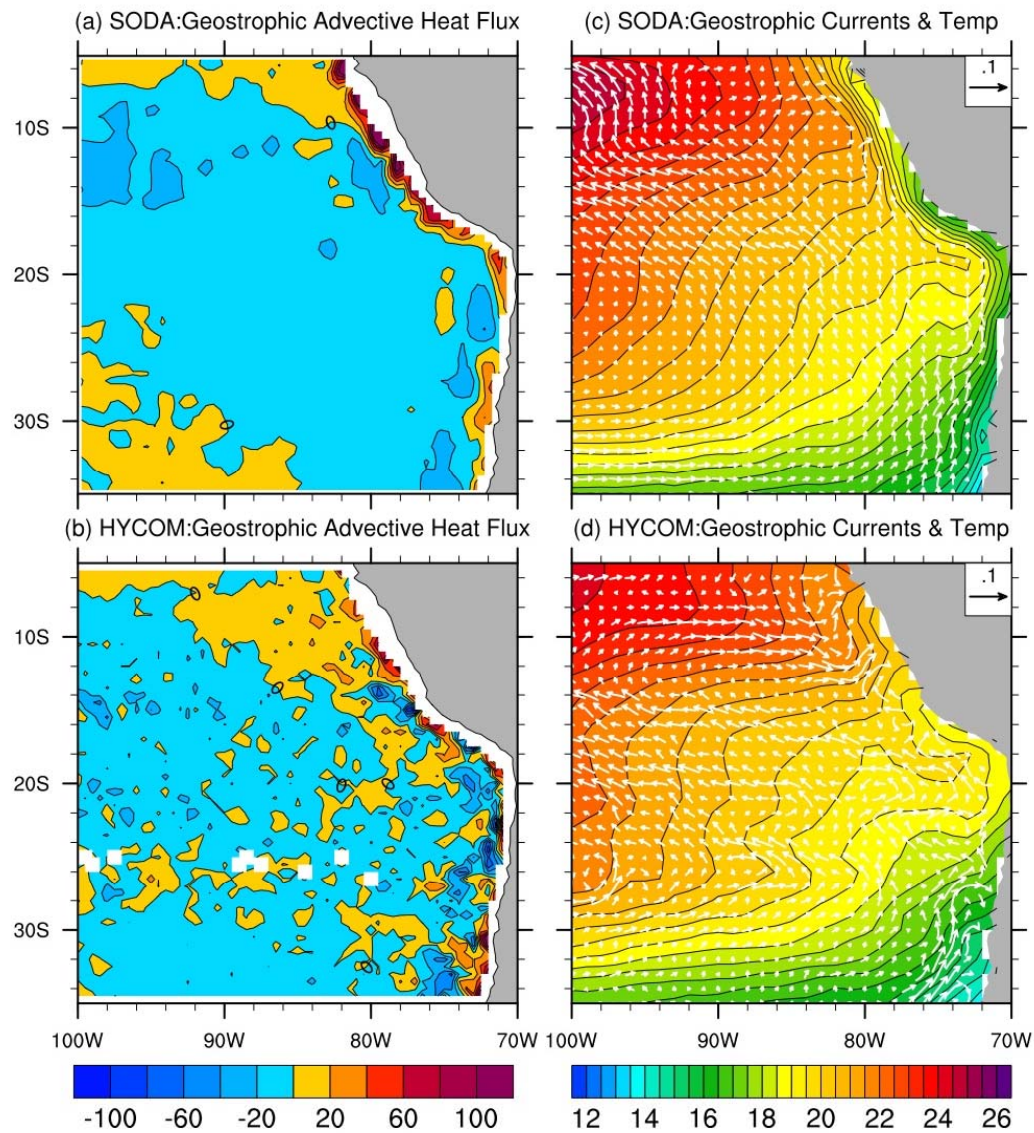**(b) SODA:Temp**

(c) HYCOM:Temp

HYCOM: Net Surface Heat Flux

Comparison of heat budget at 85W, 20S

	Colbo and Weller (2007)	*HYCOM*	*SODA*
Surface heat fllux	*44*	*18*	
Geostrophic	*-20*	*-45*	*-21*
Ekman	*6*	*-44*	*11*
Eddy flux div.	*-30*	*42*	*-19*

Ekman currents −> total - geostrophic

Upper 50m

(a) SODA:Geostrophic Advective Heat Flux

(b) HYCOM:Geostrophic Advective Heat Flux

(c) SODA:Geostrophic Currents & Temp

(d) HYCOM:Geostrophic Currents & Temp

Upper 50m

(a) SODA:Ekman Advective Heat Flux

(b) HYCOM:Ekman Advective Heat Flux

(c) SODA:Ekman Currents & Temp

(d) HYCOM:Ekman Currents & Temp

SODA: Ekman Heat Flux

Ekman Transport $\longrightarrow$ 3.00 m^2s^{-1}
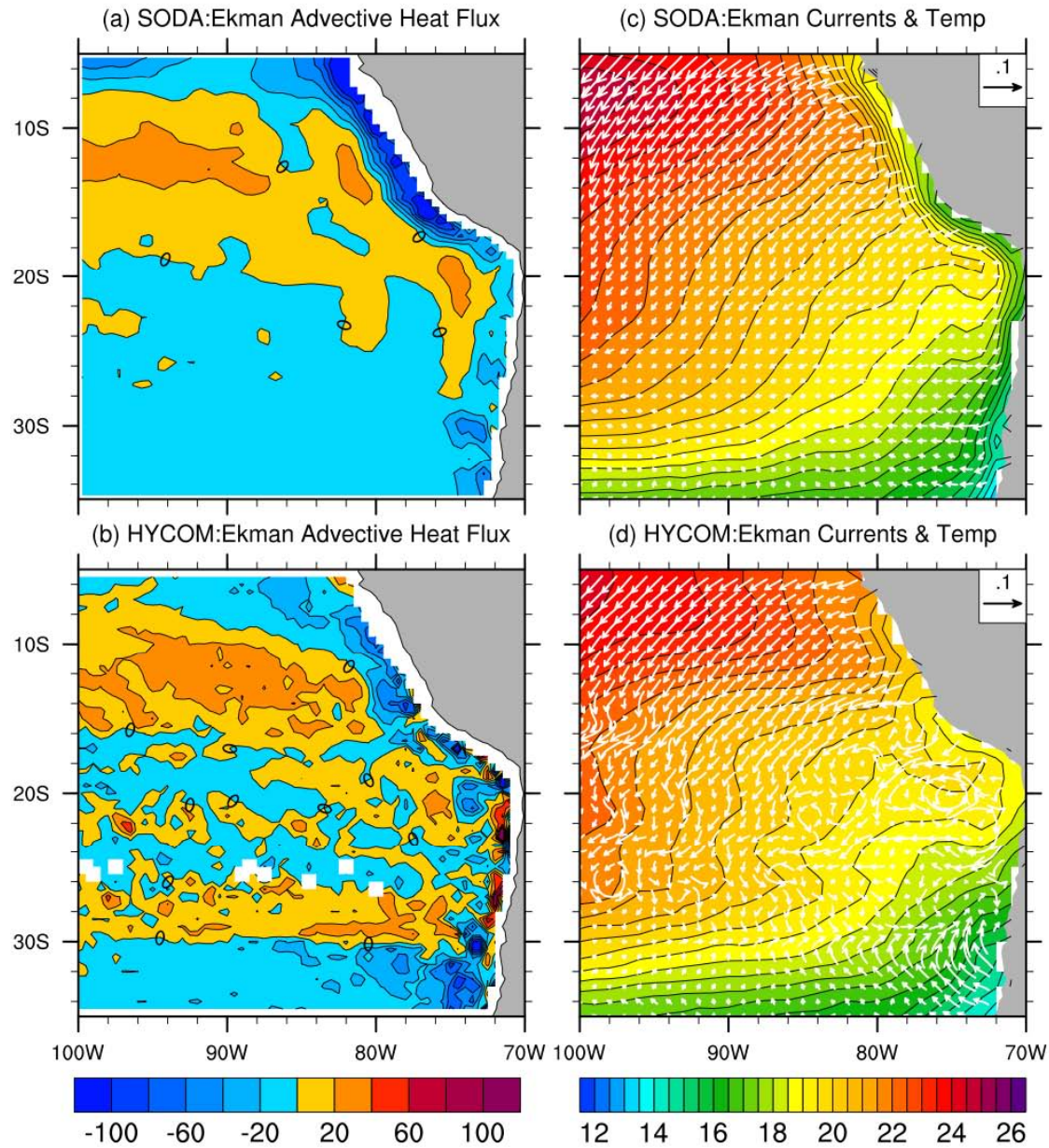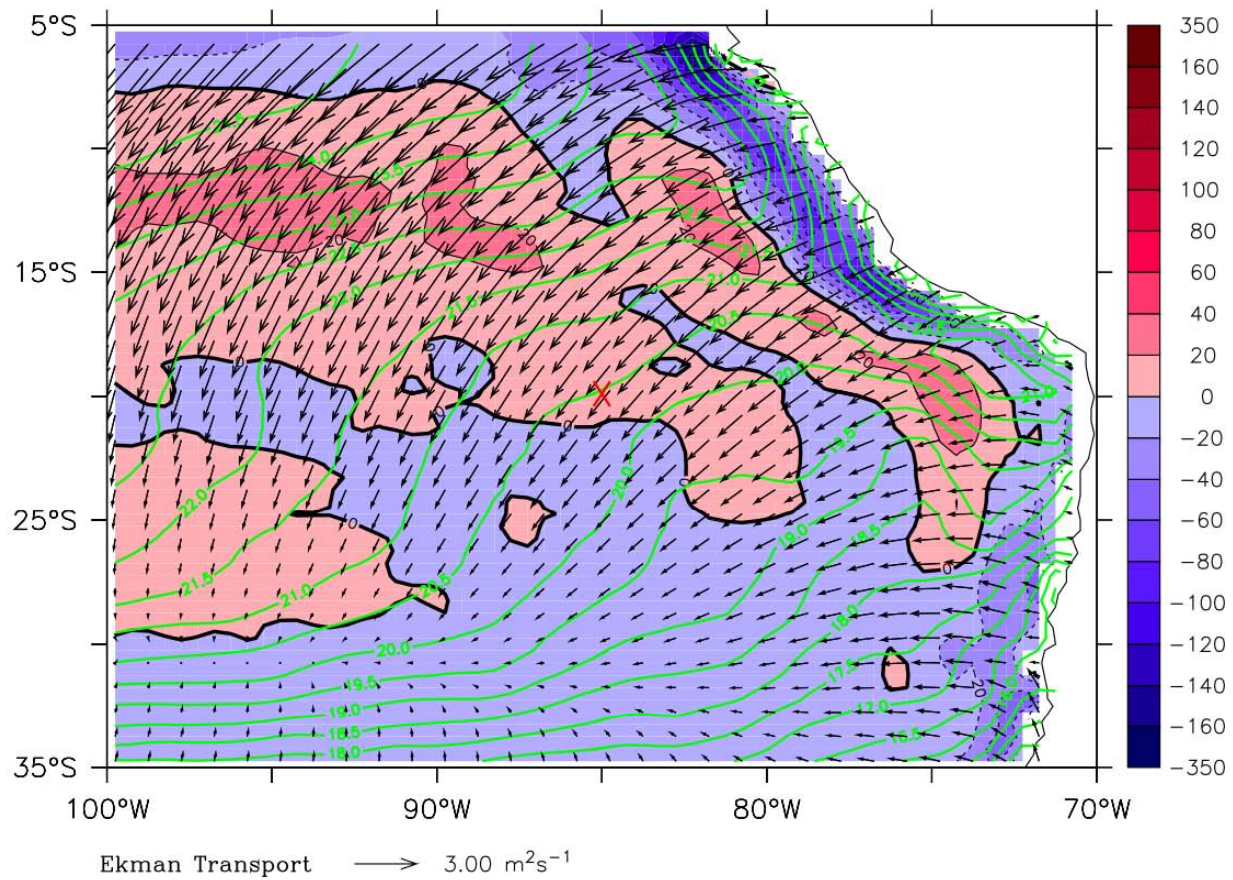
Sea Surface Eddy Kinetic Energy ((cm/s)^2)

$EKE=(u'^2_{geo}+v'^2_{geo})/2$

Mar 8 2005

Mar 18 2005

Mar 28 2005

$(u',v') \longrightarrow 0.50 \quad ms^{-1}$
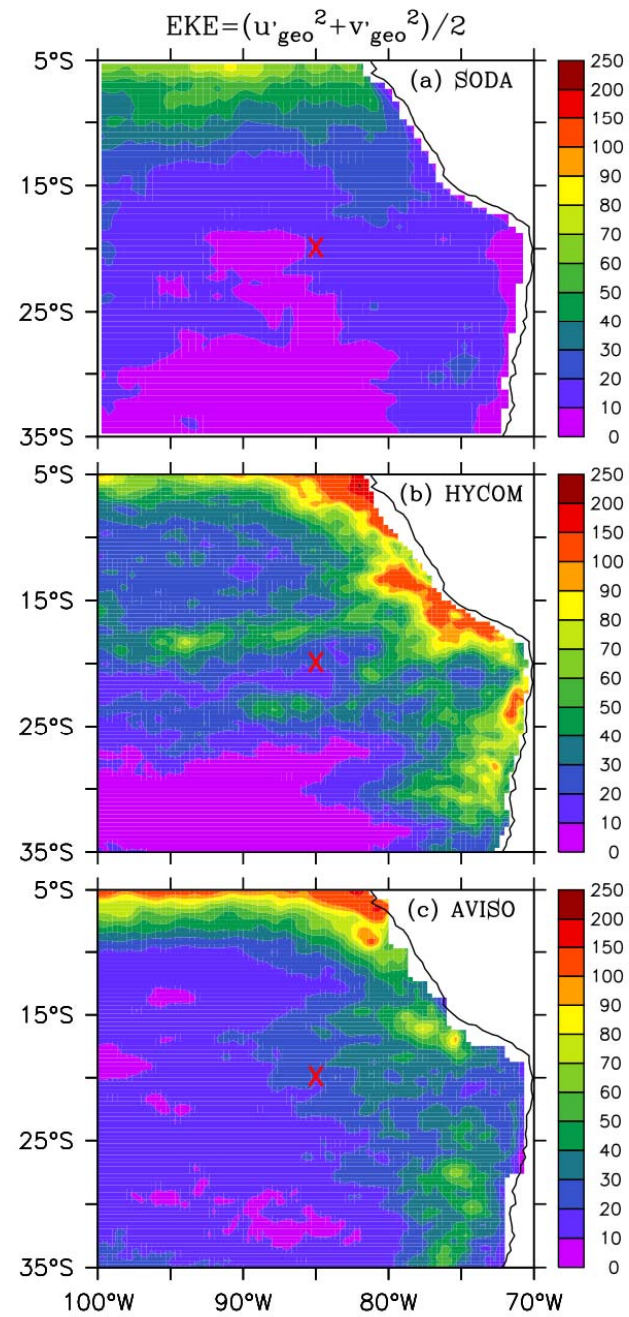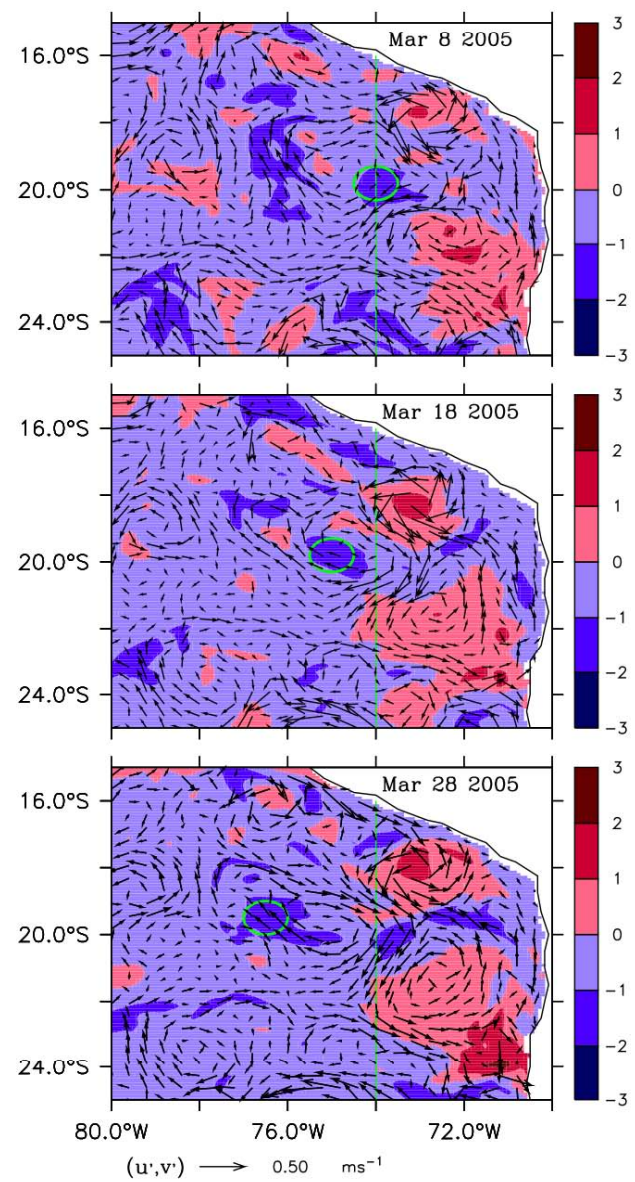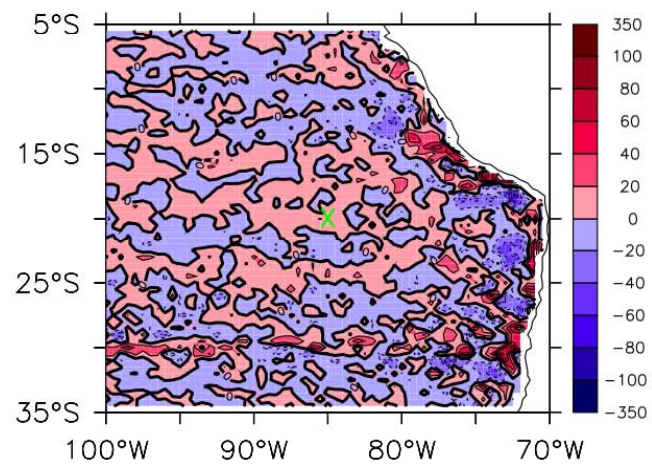
(a) SODA: Eddy Heat Divergence
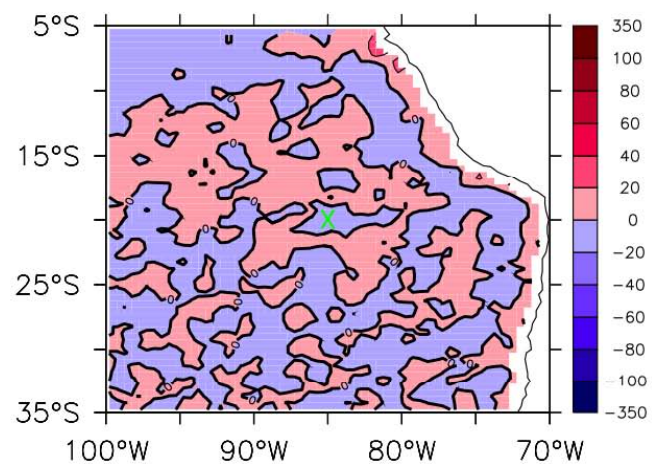
(b) HYCOM: Eddy Heat Divergence

Heat budget in the upper 50m (100W-80W, 30S-10S)

	HYCOM	SODA
Surface heat flux	11	
Geostrophic	-5	-9
Ekman	3	6
Eddy flux div.	0.1	-0.1

Conclusions

*Geostrophic transport in the upper 50m causes net cooling in most
of the stratus cloud region*

*Ekman transport provides net warming north of the IMET site and
net cooling south of the IMET site*

*The eddy heat flux divergence term can be comparable to other terms
at a particular location such as the IMET site, but it is negligible for
the entire stratus region when area averaged since it is not spatially
coherent in the open ocean.*

*Surface buoy observations in locations both north and south of
the IMET site would be useful.*